DISCUSSIONS AND COMMENTS
ROADSIDE GRADING AND DRAINAGE

Wilbur H. Simonson, Moderator

W. H. Simonson: Our discussion here today is expected to set a pattern for nationwide study of roadside grading and drainage design, and field practice. The Committee on Roadside Development made plans before the war toward integrating principles of roadside grading and drainage with highway design, construction, and maintenance in all States. Coordinators in each of the Divisions of the Bureau of Public Roads held meetings in 1941 at which this integration was studied and discussed. Following the war interruption, coordinators were reappointed in 1947 and the study continued.

Two facts now stand out. First, we need more information on dominant trends in grading and drainage design now appearing in graded cross-sections installed on newer highways in the various regions of the country. Secondly, we need a more complete picture of how grading and drainage design and practice now in use can best be adjusted to meet varying conditions of climate and rainfall, land use and soil erosion. We know that improved cross sections and streamlined grading have resulted in better drainage, increased traffic safety, better appearance and economy in maintenance. We also know that adequate grading and drainage design is closely related to complete control of erosion. Measures to stop highway slope erosion must immediately follow finish grading, to be fully effective.

We will begin our panel discussion by asking this question: "What can the highway engineer do in contributing toward the conservation of water resources in his State and locality? Professor Elwood might give us his comments on this.

P. H. Elwood: Ground water is the great source of our water supply. I would suggest that the highway engineer study the problem of retarding the flow of water in his drainage design. If he can retard surface water and cause it to be absorbed, rather than run off too rapidly, he can accomplish two things. First, he can help to raise ground water levels. He can also decrease erosion damage to his highway structures and embankments. Check dams, and well designed intercepting dikes and channels are examples of what I mean. There is great need for more study along these lines.

H. J. Neale: Where you can acquire wide right-of-way to retain existing forest growth, you can do much toward holding back surface water by absorption. This will reduce the volume of water that will reach highway drainage channels and structures.

W. H. Simonson: The State of Michigan in certain counties now acquires 400 feet of right-of-way through forested areas. This forest growth prevents snowdrift formation on the traveled way. It is also a means of water conservation. Surface water infiltrates the leaf cover under forests and is absorbed with a resulting higher local water table and less run off. Mr. Izzard may have some comments on this point.

Carl Izzard: The important thing in drainage design is to consider where the water is coming from. No one should attempt to design drainage for the highway unless he first determines the size of the drainage areas contributing water to the highway. On the small watersheds the most important thing is the type of land use. We have records establishing peak run-off to be expected on the Coastal Plain of Maryland, in the Appalachian Highlands of Ohio, or the Great Plains of Nebraska depending on whether you have crops in rows, furrows, up and down hill, or terraced ground. Furrows up and down hill may result in as high a rate of run-off as you have from urban areas, with their extensive roof and pavement areas. Next in order of high run-off rate is an area of pasture or mixed crops. Below your pasture you have woodland where peak surface water run-off rates are very low. If you could keep all your watershed areas in woodland, most of your highway drainage problems would disappear. We can't do that of course.

The crux of the problem is to get this basic information to the hands of the men doing the designing of our highways. As Webster says, "research is studious inquiry, usually critical and exhaustive investigation or experimentation, having for its aim the revision of accepted conclusions in the light of newly discovered facts." Our job then is to get the facts, examine them critically and then revise our accepted conclusions. That is what our Committee on Surface Drainage is trying to do. We are trying to get at the facts, in which we can analyze our accepted conclusions and put our drainage design on a truly scientific basis.

H. J. Neale: Mr. Izzard, where you have a wooded watershed area and you expect that to be changed to cut over land, to pasture, and then to cultivated land use, what factor of safety do you use in design of drainage structures?

Carl Izzard: You might better ask what ought you to do? For example on our Shirley Highway outside Washington, we note that the land within ten miles of this highway on both sides, all the way to Occoquan, will eventually be developed as an urban area. Drainage structures all the way should be designed in anticipation of eventual urvan area types of run-off. Those changes in land use should be considered for the life of the new highway. Stage construction may be called for.

H. J. Neale: How can you anticipate flash floods in short periods of excessive rainfall in your drainage design?

Carl Izzard: It is economically impossible to design drainage facilities for the maximum storm that could occur. The tendency is to take a fairly frequent storm--to be expected over a 10-year period--and design culverts to meet expected peak run-off during that ten-year storm. Bridge waterways by contrast should probably be designed for any storm that might occur during the period of expected life of the road. There should be no possibility of a road being closed to large volumes of traffic because of stream floods.

This suggests another point: Peak rates of run-off from large watershed areas should be analyzed on the basis of actual run-off of streams. It will never be possible to put a lot of pastureland into a formula and say "This is the peak run-off for a 50-year storm or a 100-year's flood expected on this stream. The only way to be sure is to collect streamflow records for at least twenty years on each stream. Then you will have statistics to predict magnitudes of flood waters with at least reasonable accuracy.

On small watershed, the effects of land use do not permit the same accuracy of prediction. The effects of land use tend to be obscured when water flows into large rivers because of channel storage. On small watersheds water runs off quickly with only a very small percentage stored in stream channels. The fact to be considered is how much of the water is temporarily held back before it reaches the highway and its drainage structures. The time lag factor is important here.

H. J. Spelman: You can hold more water above ground with vegetation than you can below ground with dams. We can do more to conserve water by encouraging proper revegetation of the entire highway right-of-way.

W. H. Simonson: That is a good point, Mr. Spelman. I want to suggest that all of you come to our meeting this evening and hear Mr. Potter's paper on the problem of run-off from small watersheds. As Mr. Izzard says, data have been successfully collected on surface run-off from large stream watersheds. We know much less concerning run-off from the small watersheds draining to the highways.

The next question is addressed to Mr. Wells. Do you have drainage problems resulting from changes in land use above your highways? Do these problems warrant research, further investigation, and study?

N. M. Wells: Mr. Izzard pointed out some of the results of watershed land use changes from forest to pasture to cultivated crops. We have another problem to be considered. Large paved areas at outdoor theatres, gasoline stations and the like create an acute drainage problem when they drain onto the highway. So I would invite further questions from State representatives in this audience. What are your other problems of highway drainage that are not cared for by present policy or legislation? These might well be referred to the Committee on Roadside Development for further analysis and investigation.

Torbert Slack: Mr. Simonson, our farmers in Louisiana consider that their farms should be drained onto the highway. As new agricultural lands are cultivated, we have changes in land use. Our problem is to get the water off the highways as quickly as possible and into some stream or the Gulf of Mexico. Drainage Boards and other State agencies have encouraged land drainage until water tables have been lowered in many localities. How far should we go in encouraging this rapid drainage of farm and highway areas? In two parishes, for example, they are holding drinking water in storage. We have to hold surface water back on the land or we do not have the moisture we need to grow grass, ground cover and trees on our highways. There is certainly a need for more study and investigation here.

C. E. Shumate: I was very much interested in the remarks of the gentlemen from Louisiana and New York. Our irrigation farmers in Colorado -- and thinking of the current water shortage in New York -- could very well take care of the needs of New York State for some time. I would like to recommend to the committee more study of increased run-off due to land use and particularly the development of suburban areas. We have one particular spot in Colorado where our drainage developed into quite a serious problem not only from the standpoint of the highway user, but the adjoining property. We made an investigation of this rather small drainage area; the particular highway had been constructed about 15 years ago, had given no trouble until three and one-half to four years ago. We sent our engineers into the area and found on a 27-acre subdivision that we had eight and one-half acres of roofs. Of course, you can readily see what happened. The ground part of the development was rolling, covered with heavy sod and buffalo grass, which, if you gentlemen are not familiar with it, will soak up water like a sponge. That turf was all taken off, the street was paved, and in addition, we had some eight acres of roof. We have cautioned our design engineers to give thought to enlarging their drainage structures when they see an area that might be developed.

From the standpoint of water, I agree entirely with the remarks that have been made here this morning. We should retard the flow of the water onto the highway, and retard its flow away from our highways. In the arid country, the western States and the Rocky Mountain areas, some of the biggest damage we have had has been from water going through our structures.

W. H. Simonson: Mr. Shumate is our coordinator in the Colorado Division. We had now better go on to the next question. It is: "What is your greatest single grading and drainage problem within the highway right-of-way?" Mr. McManmon of Massachusetts may have comments on this.

J. V. McManmon: In view of what has been said here about adjacent land use and water reaching the highway from adjacent lands, I believe that obtaining the proper angle of repose of cut and fill slopes may be one big problem. We should have some information to help us determine:

1. The proper relationship between various types of soils and slope ratios of cuts and fills.
2. The grading design of areas where the transition from earth cut to fill takes place should have more study.
3. We should study and consider better streamlined cross-section grading, and improved grading and drainage design to handle water that reaches the highway from adjoining lands.

W. H. Simonson: Is there any one who has a particular problem on roadside grading that requires research--any volunteers? Is there any further investigation needed to cope with cross-section design problems in your State?

Mark Astrup: Oregon has adequate cross-section grading standards. Our problem is to get the contractor to meet these standards. We do not have trouble getting slopes sufficiently rough so that topsoil will bond to them. We grade some slopes using slope boards to hold topsoil from sliding.

Wesley L. Hottenstein: In Pennsylvania since the war, use of stepped (terrace) slopes is on the increase. Such slopes are shown in our plans where required. Attitude of project engineer is most important in getting proper slope grading.

W. H. Garmhausen: We use both the continuous and the stepped slopes in Ohio. We rarely have $1\frac{1}{2}$:1 slopes except above rock outcrops. Best results follow use of 2:1 (or flatter) continuous slopes.

Question: What is your experience in the use of motored grading equipment to round and warp earth slopes?

J. V. McManmon: Our specifications permit grading by motored equipment on 3:1 slopes with a tolerance of 3 inches per station control length with respect to lines and grades shown on plans. (Connecticut specifies a tolerance up to 6 inches per station.) This results in lower yardage excavation costs. Topography largely determines use of machines. More interest by the contractors in slope grading since our use of 3:1 slopes has permitted increased use of the prime-mover types of grading equipment. Increased safety and lowered maintenance costs have followed the use of flatter slopes.

W. H. Simonson: Can you report other improvements in grading and drainage practices in your State, such as the elimination of the old costly hand-labor practice of "sandpapering" slopes?

F. H. Brant: Our greatest progress in North Carolina has been in use of heavy type of grading equipment. Transition grading between cuts and fills is our greatest problem, together with matters concerned with supervision of finish grading by the resident engineer. Our grading standards are improving and we have increased interest by our contractors in streamlined grading work.

W. H. Simonson: A problem in all regions has been elimination of slope "sandpapering". Increased use of 3:1 and flatter cuts and fills is desirable to gain machine economy in earthwork. Greater tolerance in finish grading specifications permits a rougher slope that will retain mulch and seed. Massachusetts permits 3-inch variation per 100 ft. station from lines shown on plans. Connecticut permits as much as 4-inch to 6-inch tolerance per 100 ft. station length in finish grading. Specification tolerances of this kind are doing much to reduce the unit costs of earthwork excavation, with additional long-term savings in maintenance.